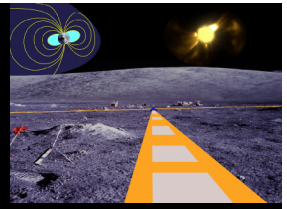
Radio Observatory for Lunar Sortie Science (ROLSS) and The Dark Ages Lunar Interferometer (DALI)

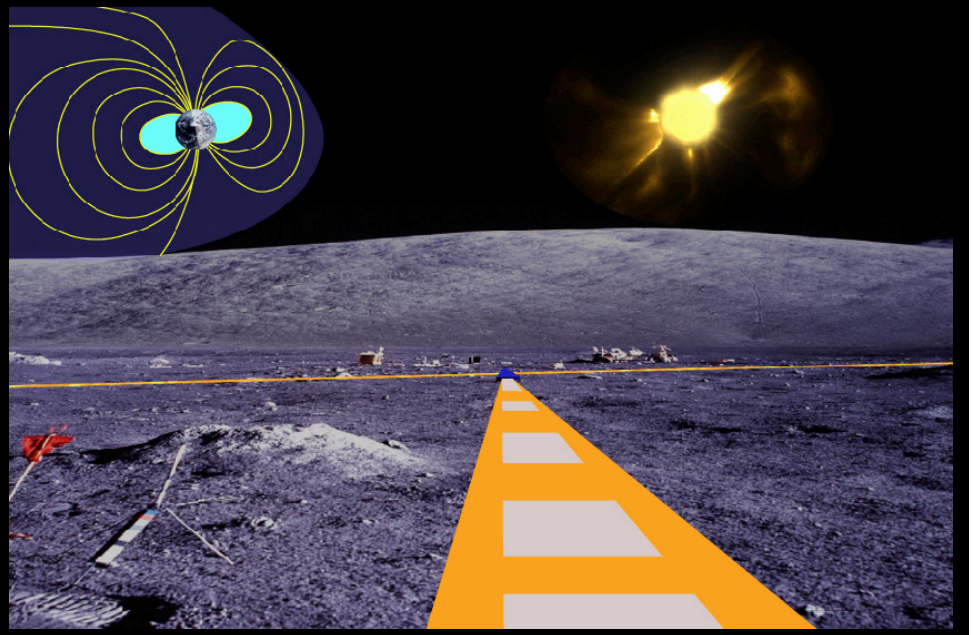
J. Lazio (NRL)
For the ROLSS and DALI teams

Radio Observatory for Lunar Sortie Science



Long-wavelength interferometer on the Moon's surface

- Key science
  - Particle acceleration
  - Lunar ionosphere
  - Pathfinder to larger (EoR and Dark Ages) arrays
- Technical description
  - 30–300 m wavelength (1–10 MHz frequency)
  - Antennas formed from conductor deposited on polyimide film
  - Central electronics package (CEP) for receivers, downlink, power
  - Data processing on ground



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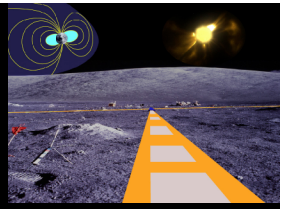
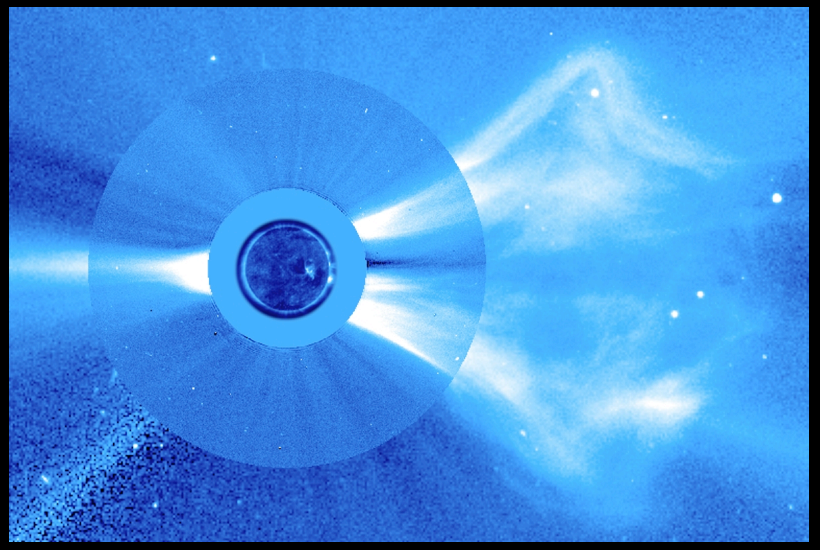
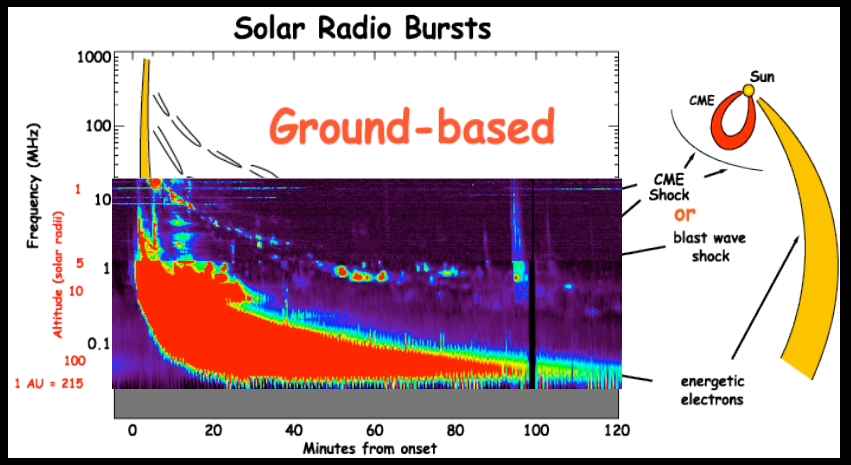
Key Science
Particle Acceleration



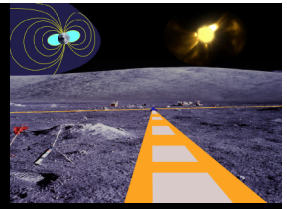
- Key aspect of particle acceleration mechanism is the low energy population which provides the "seeds" from which the highest energy particles result.
  - Low energy particles emit, and are best studied at, the longest wavelengths.
- Within the inner heliosphere (2–10 solar radii), intense electron beams produced.
- Sun is nearby.
  - Physics can be studied in great detail.
  - Technical requirements on ROLSS less demanding.

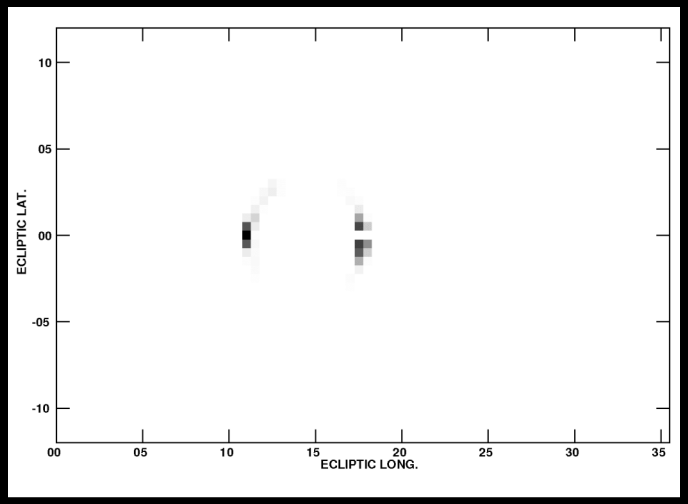


SOHO image of coronal mass ejection

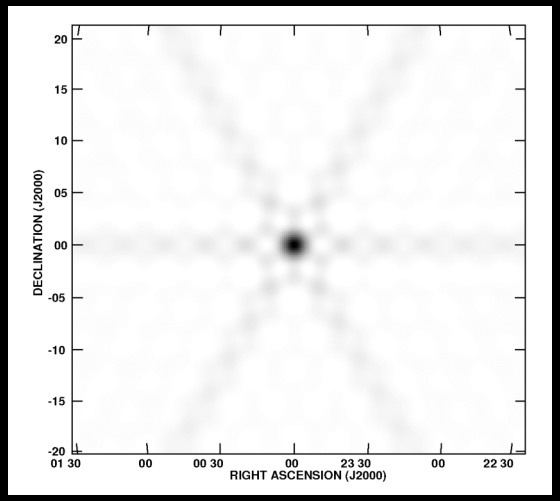


ROLSS Key Science



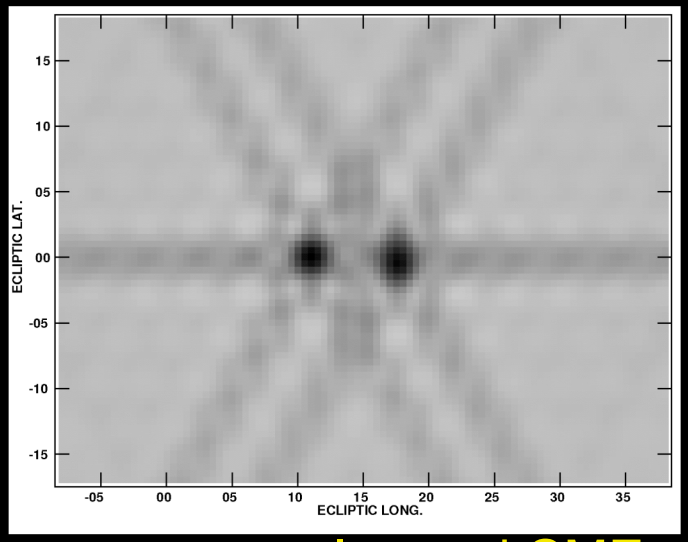


Model CME

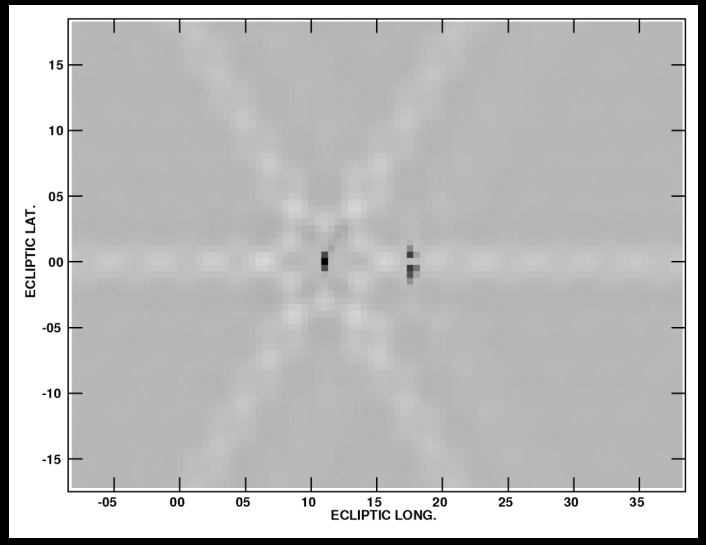


PSF

3-arm interferometer, 16 antennas per arm

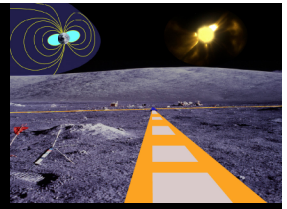


Imaged CME



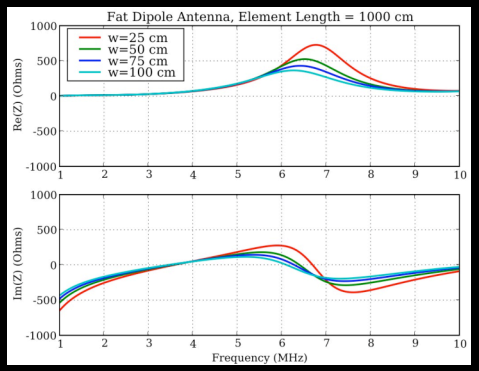
“CLEANed” CME

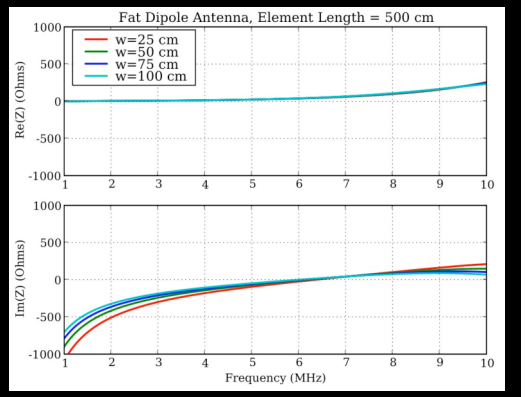
ROLSS Technical Development



Low-mass antenna requirement

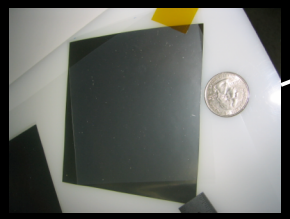
- Want many antennas
- Ground-based antennas ***too*** massive
- Polyimide film substrate an appealing concept
- Lunar surface different than usual conditions for antenna simulations

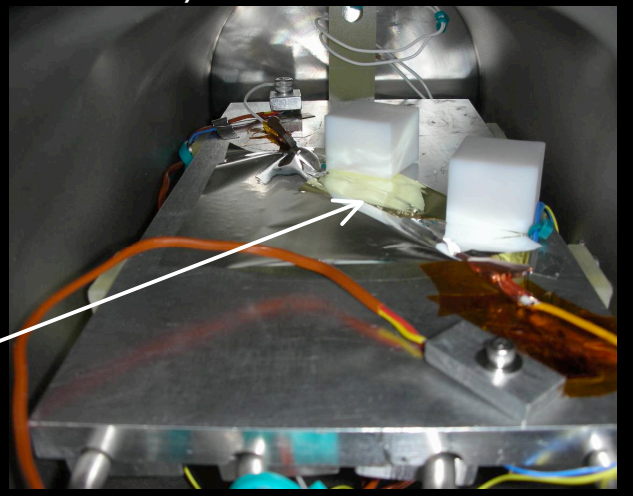




Antenna RF simulations (NRL, JPL)

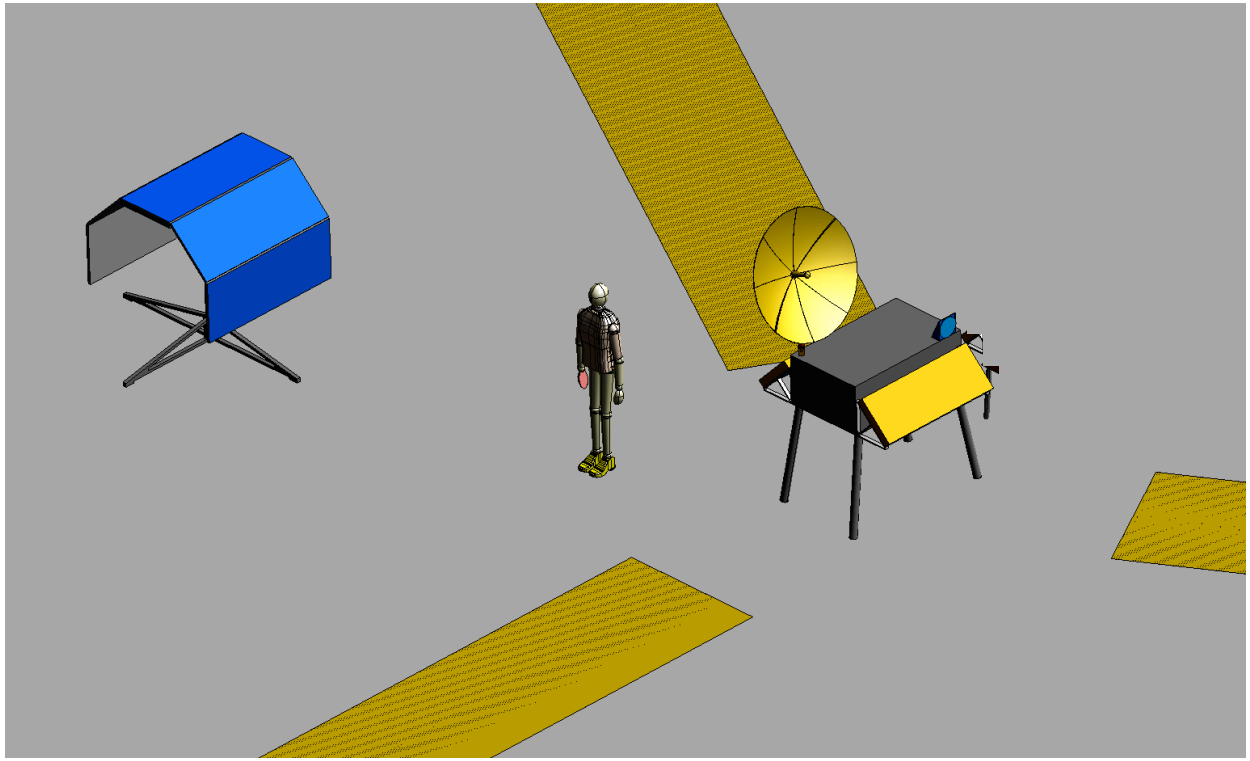
LWA prototype antenna





Testing polyimide film in lunar conditions (Colorado)

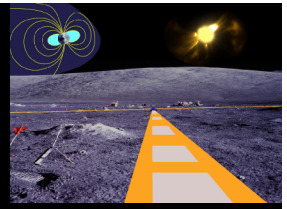
ROLSS Mechanical



Operations concept: (CONOPS)

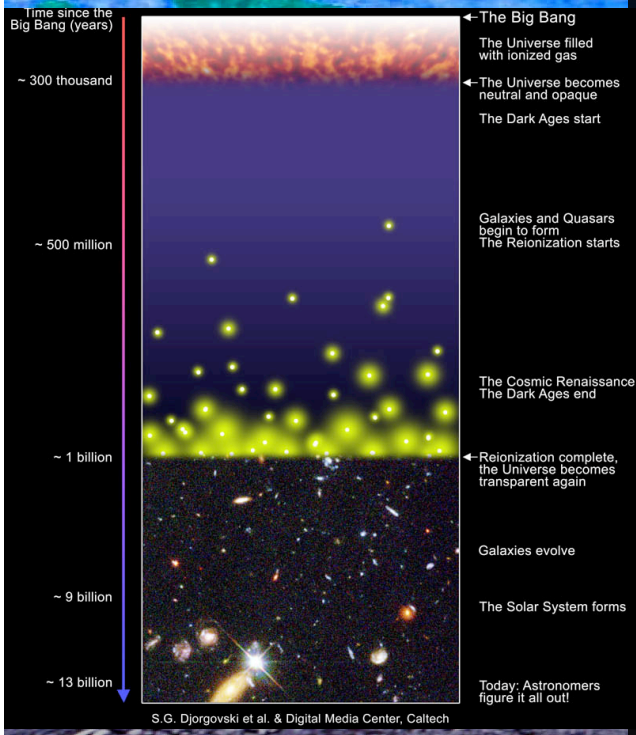
- Solar panels provide power during lunar day.
- No nighttime operations
- Central electronics package (CEP) houses science antenna receivers, C&DH, ….
- Parabolic antenna for Ka-band downlink
  - Constant fractional bandwidth downlink scheme to moderate data rate

Technology Roadmap



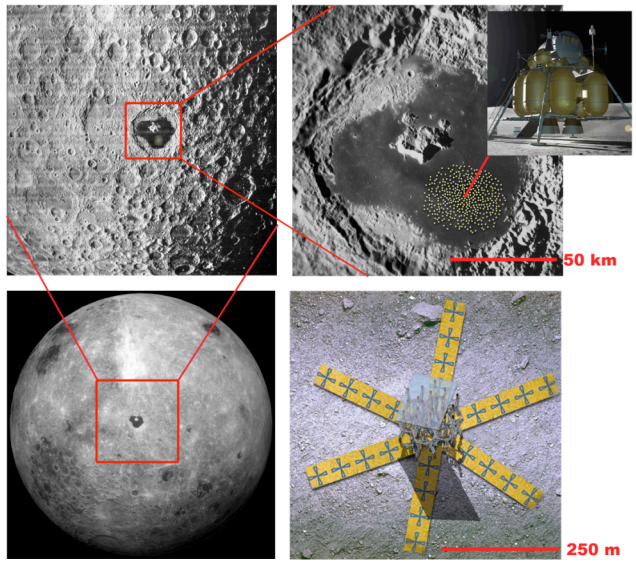
- Antennas
  - Initial work promising
  - More detailed simulations, verification
  - Develop and deploy prototype antenna
- Ultra-low power, ultra-low temperature electronics
  - Reduce power (mass) requirements ⇒ significant savings (10x or more)!
  - Reduce thermal management requirements
- Robotic deployment methods
- Phased array antenna for downlink
  - Develop efficient Ka-band array
    - X-band phased arrays in use (e.g., Messenger),
  - No moving parts
- Alternate data transport mechanism from science antennas to CEP
  - RF wireless?
  - Laser?

The Dark Ages Lunar Interferometer (DALI)

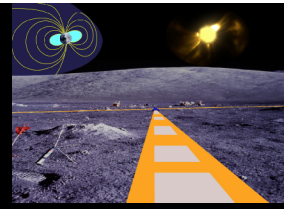


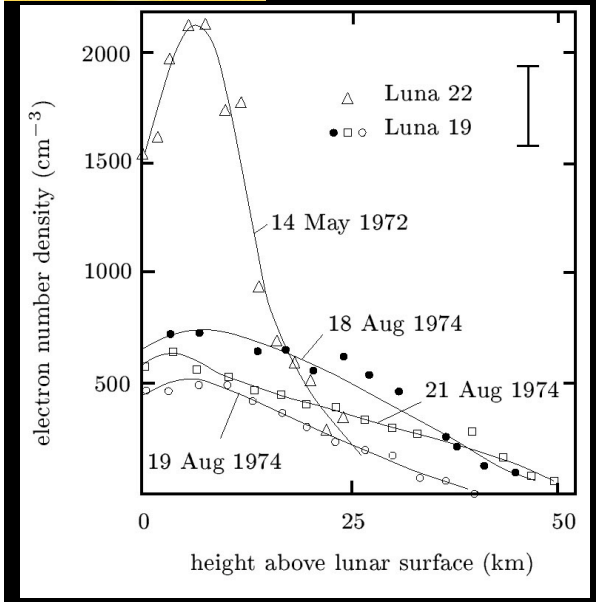
- Image the H I emission/absorption signatures against the CMB
  - Significant astrophysical/cosmological return — Direct probe of this cosmic epoch
- Constellation System opens avenue for science exploitation of lunar far side
- Technology development required over next decade

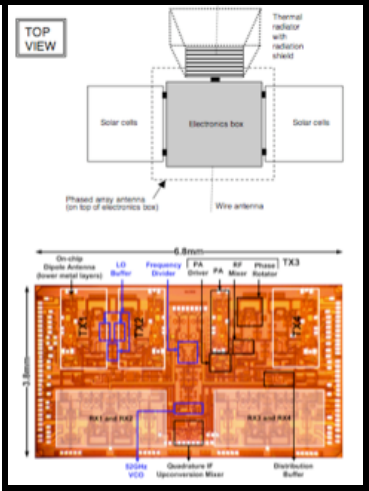
Concept study funded by Astrophysics Mission Concept Studies program



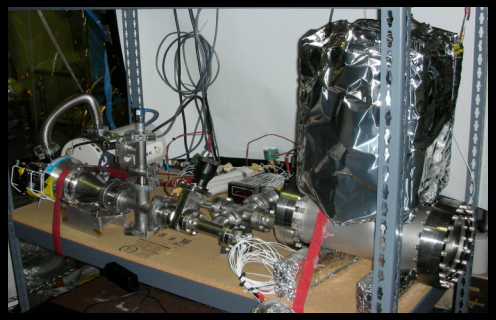
Related Work

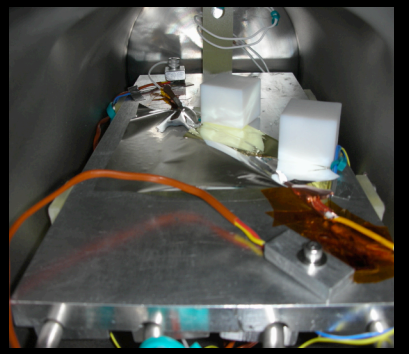






Lunar plasma density





Lunar Array Precursor Station (LAPS)

- Use riometry technique to probe lunar plasma environment.
- Affects lowest frequency of radio telescope operation.

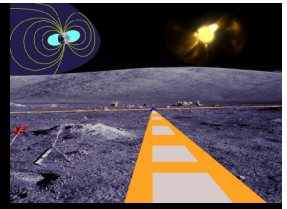
Jones et al. poster

Low Frequency Radio Astronomical Antennas for the Lunar Environment

- Low mass antennas a critical technology for lunar arrays.
- Laboratory testing of antenna concept for lunar array.

Burns et al. poster

Summary



- Key Science: particle acceleration both fundamental astronomy & physics and potentially important for space weather
- Basic instrumental design can meet scientific goals.
- Instrumental concept fundamentally sound.

  I.e., antennas on polyimide film arms
- Technology development needed

  Much of the technology development might be more broadly useful, e.g., ultra-low power, ultra-low temperature (U-U) electronics, higher data downlinks, ….